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The leading as a factor of readability: development of the methodology for educational use

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Abstract

The work is dedicated to the development of methodology for assessing the readability on paper substrates (as textbook samples) and laptop screens (as web content samples) and analyze the influence of leading on the reading speed. New approach: the readability was assessed by the continuous reading speed of dissociated texts on paper substrates and laptop screen. The research was conducted on the sample of 100 student age persons in Ufa city, Russian Federation. It is found that the dependence of continuous texts reading speed on the paper substrates and laptop screens from the leading has a maximum in range of 1.6–2.2.

Keywords: Education, Leading, Qualimetrics, Readability, Reading speed, Text.

Introduction

In recent years, it is observed a decrease in demand for printed media and so in electronic book readers and in whole electronic media. Serious, but technically avoidable lack of electronic publications is a lower resolution of text on computer or book reader screen in comparison with its printing reproduction. The consequence is a reduction in the readability of electronic text, large burden on the user's eyes than when reading printed material. These problems are especially sharp in educational process because of the influence of readability on the text perception and so on the quality of education in the end. The perception of the text presented in digital form depends on the characteristics of the screen display. The perception of the printed text depends on some spatial characteristics of the page and font used. Therefore a necessity to adjust the typesetting of print and electronic media rules in order to improve readability appears.

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The aim of the research was to develop the methodology for assessing the readability in education and to investigate the perception of the text-based information from one of the main spatial characteristics of a type page area — leading. The research was conducted by direct interview and questionnaire. It involved 100 student age respondents from the Institute of Professional Education and Information Technologies of the Bashkir State Pedagogical University and Military department of Ufa State Aviation Technical University.

1. Readability investigations

1.1. Readability and main features of text and font

The analysis of researches in the field of readability shows insufficient scrutiny of issues related to finding the best representation of the spatial characteristics of textual information. Thus, the research of perception of the spatial characteristics of the type page area on the example of leading seems to be much actual. Readability is a property of the text material which characterizes the ease of perception of it by a man. The main readability criteria of the specific typographic sample is reading speed of this sample. The measure of readability is the time in which one can read the text.

Also readability is one of the major advantages of a good ("readable") font. The readability of fonts is determined by speed, i.e. quickness of perception, and the readability of individual characters, and the text as a whole, as well as the accuracy of comprehension without undue stress and fatigue. When reading due to a readable font the eye pressure doesn't increase (Glushkova, 1987), the attention concentrates mainly on the information itself, rather than the means of transmission. So it is advisable to choose a set of quality and legible fonts to text typing on the prepress stage, as well as the correct choice of other text typing parameters and layout. Font readability is influenced by:

1. Form of font characters: a picture or font type, size, sign proportion ratio of the width to its height, rhythm shape, weight, color;
2. Typographic composition: the string length or font field width, space around the line or font field, leading, the form of lines, rhythm of lines and text composition, color solution;
3. Font definition: the ratio of the font color to the background color, texture, quality of performance;
4. Font clarity: recognition of signs, it's differentiation, justified shapes simpleness, represent of the content.

Necessity of obeying the readability requirements caused by psychophysiological characteristics of man, manifested in the process of reading and understanding the text (Smirnov, 2007).

Question of the font size influence on legibility in a coherent text is well studied and confirmed by practice. Most readable font size for the text connected to adult skilled readers is the size of 10 points (Dubina, 2004). Smaller font sizes are read with a lot of stress when placing signs. If the font is too small, the reader is often "lost line": having read to the end of the line, hardly finds the beginning of the next one. With too large font sizes line, by contrast, are shortened, resulting in some of the transitions to the next line. Because of the lower resolution of the PC screen font characters legibility is deteriorates. Therefore, the screen font has to be larger than paper printed.

James Felichi (2004) gives several ways to determine the optimal length of the line:

1. The optimal length is equal to 1.5-2 lengths of alphabet line length. Alphabet line length - a line that contains all lowercase alphabetic characters.
2. Optimal length line should contain 9.10 words on average consist of five letters each.
3. The minimum length of the line is 27 characters, the optimum length - 40 characters, and the maximum - 70.

Leading factor is calculated by dividing the line spacing to the font size (in points). Line spacing - the distance between the baselines of the text. Baseline – an imaginary line along the bottom edge of the main element of character. In Fig. 1 shows the basic lines of text, and the distance between them.

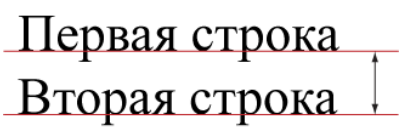

Fig. 1. Line spacing

1.2. Readability researches

History of readability research dates back more than 100 years. Cattell (1885) attempted to assess the readability by tachystoscopic measuring of the recognizability threshold. Tachystoscopia is allow to determine the minimum time required for recognition of characters, words, groups of words. Cattell found that sight when man reading is not moving monotonically in line, but jumps with short intervals, covering just eight or nine characters. With each fixation eye takes three or four letters. But in fact, sight motion when reading text is even more irregular, since fluency, knowledge of the meaning and syntactic structure of the text allow to not peer into individual letters.

Based on these studies, Cattell placed lowercase letters of the alphabet in their degree of recognizability in sequence. Sanford (1987) had repeated studies, but using a different font, he received another letter order. This suggests that the fonts do differ in their recognizability.

A report by Pyke (1926) summarized the results of studies of readability. Report noted the fragmentation of research and the lack of a systematic approach to the research of text recognition and readability. Pyke himself singled out 15 readability criteria:

1. reading speed;
2. recognizability threshold distance;
3. volume of perception;
4. threshold of focus;
5. fatigue;
6. number of fixations;
7. number of returns;
8. eye movement regularity;
9. rhythm of reading;
10. readability factor (sum of letters area, divided by the total area of perceived letters);
11. specific readability (the multiplication of the readability on the printed area of letters);
12. height of letters;
13. height of signs;
14. subjective judgments of readers;
15. aesthetic judgments of readers.

Based on the analysis, Pyke concluded that readability is not to be confused with the letters and words discernibility, it should be studied separately from the discernibility. He proposed to assess the readability by comparing the text read with that is understood when read. Thus, it was concluded that the readability should be judged not by the disparate characters, but on the examples that contain meaningful text. Then there was the question of the speed of reading. The reading speed means the amount of time which takes to read a particular text. First reading speed as a readability criteria was proposed by Weber in 1881, but actually became considered after the Pyke's report.

In 1920th U.S. researchers (Tinker, Paterson, 1929) got the following results:

1. Text typed with capital letters, read by 11.8% slower than typed with upper and lower letters;
2. Italics not slow reading speed, if used short;
3. Bold no less readable than light, and sans-serif fonts are not inferior to the readability of serif fonts.
4. Fonts from a size 8 to 13 are equally readable with a size optimal for a given length of the string.

Black text on yellow paper, green or blue text on white paper, read a bit slower than the black text on white paper. White on black read about 10% slower than black on white.

In the USSR the research of a comparative readability of fonts was conducted in 30-40th of XX century in OGIZ research institute, in 50-60th of XX century in the department of movable types of Polygraphmash institute. Artemov (1933) proposed to distinguish the concept of visibility and readability of font, as readability significantly affected by the certain physiological reading characteristics of the reader, while the visibility of the font depends on the quality of type faces and features of the person's vision. In 1973, in the Moscow Polygraphic Institute Geshev (1973) and Kolosov where investigated the effect of font size, string format, inter-word spacing and leading on the text readability. It was concluded that the optimal value of inter-word space is constant and independent of other factors. The optimal value of the font size and format of the string is the smaller, when the font is more readable (Tokar, Zilbergleit, Petrova, 2004).

Wide paragraph gives the best results in reading speed, but eyes get tired faster. The fact is that after reading one line, the eye must be tuned to the next line. And in a long line, the eye has to overcome a greater distance, making it harder to find the following line (Vakorin, 2005). Also since the late 19th century, there have been many studies on the optimal line length for printed publications made, but the ideal solution has not appeared.

Readability is also associated with the color. Text in black and white is hard to read on a computer screen. The human eye is much easier to perceive colored letters on a colored background. (Teksheva, 2008) When reading from the computer screen during the stable performance does not occur, underscoring the increasing complexity of visual work when reading from the monitor. Considering not only the speed of reading, but also the number of errors, the optimal screen colors will be slightly different. Preference should be given to the blue signs on a yellow background, the yellow signs on a blue and red signs on the green. In addition to the best color combinations, is set the screen brightness level (from 35 to 120 cd/m^2), and the total uneven brightness on the screen should not exceed 40%.

The most objective and functional method of readability researching is considered to be the method of reading speed measuring. It is to determine the time of reading a text of a given size (Tokar, 2011). And this method is used in this work. The new approach was to develop (by special software) the artificial dissociated text for use in the assessments. It was made to eliminate the cognitive component affecting to the reading speed. In this research, the text reading speed was adopted as a main criterion of specific printing solution in the hard copy version readability. When considering the various leading readability some contradictions that have led to finding the optimal ratio spacing for printed and electronic texts have been found.

2. Sampling and procedure

2.1. Sampling

As respondents 100 students (age 20-22) were selected. The experiment was conducted in daylight in the classroom of the Bashkir State Pedagogical University, Ufa, Republic of Bashkortostan, Russia.

As a stimulus material 13 dissociated texts of 1000 characters were generated. Texts where placed to individual pages with different leading values and under identical set of other parameters: font Times New Roman (known as knowingly readable), font size 14 points, margins 2 cm, indentation 1.25 cm, justification for the width of the page, text color is black, paper color is white. Selected leadings (according to MS Word 2007): 0.8, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.2. Stimulus material was printed on writing paper A4, 80 g/m^2 by electrostatic laser printer Konica Minolta bizhub C220. And so it was generated as set of PDF files to preview on the laptop. The average line length was 164.84 mm and 73 characters (include spaces).As addition line spacings and leadings on all printed pages were measured by microscope with a metric ruler, and metric leading factors were calculated. The following values (accordingly leading values given above) have been obtained (see Table 1).

In the first phase of the experiment the time of reading the texts with various leadings has been measured, and the perception of the paper printed text patterns has been evaluated. Respondents were asked to read the series of

13 variants of stimulus material with a comfortable for themselves speed, without gaps or repetitions. Reading time of each page was controlled with stopwatch.

Table 1. Values of line spacings and leadings on the printed texts

Leading (by MS Word)	**0.8**	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**2.2**
Line spacing, mm	4.56	5.66	6.21	6.80	7.35	7.95	8.54	9.04	9.64	10.18	10.78	11.33	12.50
Font size, mm	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
Calculated leading factor	1.01	1.26	1.38	1.51	1.63	1.77	1.90	2.01	2.14	2.26	2.40	2.52	2.78

For the second phase of the experiment nine texts of the stimulus material created in the first phase were selected. Leadings were the following: 1.0, 1.2, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0. At this stage, the values of text samples reading speeds from the screen of laptop Asus A52F (15.6", ratio 16:9, resolution HD (1366x768 pix), LED backlight, color profile AdobeRGB1998) were obtained. Respondents were asked to alternately read 9 pages of the stimulus material. Reading produced in Adobe Acrobat 9 Pro at full screen, fit page. Reading time was controlled with a stopwatch.

2.2. Data preparation and processing

For the preparation for processing of data obtained during the experiment Microsoft Access 2007 was used. The file structuring the data obtained was created in the program. Values of time spent on reading the text of 1 000 characters were transferred to the values of reading speed in characters per second. For the further work with the data an arithmetic average of reading speed for each leading, standard deviations, standard errors, confidence intervals $p = 0.95$ were calculated.

3. Results and discussion

On the basis of a structured database the plots of dependence of reading speed from the value of leading were drawn for printed and electronic texts (see Fig. 2) as well as the corridors of confidence intervals $p = 0.95$ for both curves. For clarity, each of the plots was approximated with polynomial curve. Plot in Fig. 2 shows that the maximum paper printed text reading speed is observed with leading 1.7. Reading speed at this point - 21.0 char./sec. Thus, it is shown that the dependence of the text reading speed from the leading has a maximum. In particular, the observed maximum lies in the range 1.6-2.2. On the plot of dependence of electronic text reading speed from the value of leading the maximum reading speed is 17.7 char./sec. It achieved with leading 1.9. However, it’s found no statistically significant effect of leading on the electronic text reading speed (determined by visual comparison of plots).

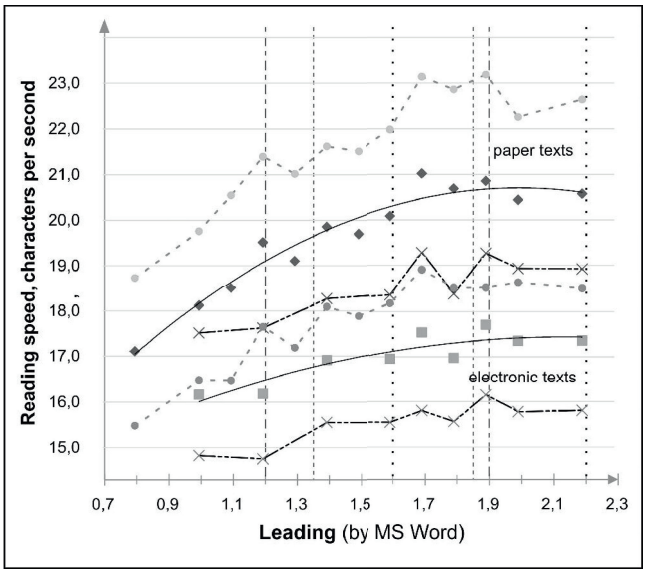

Fig. 2. Dependence of printed and electronic texts reading speed from the value of leading, corridors of confidence intervals p = 0.95

4. Conclusion

When considering the question of readability with various leadings some contradictions have been found. It has led to the need to find the optimal leading for printed and electronic texts. It was also noted that in the national researches of readability the factor of subjective perception not taken into account or had no effect on the final conclusions. Therefore, we attempted to identify the laws relating the perception of the text and its spatial characteristics. The analysis of the literature led us to the formulation of hypotheses: the dependence of reading speed from text leading has a maximum. To test the hypotheses two experiments with 100 respondents were designed and conducted. Then developed a method of processing the data, allowing to obtain the valid conclusions in terms of research objectives.

Processing reading speed data using t-test showed that the dependence of printed text reading speed from the leading has a maximum. In particular, the observed maximum located in the interval (1.6;2.2). Statistically significant effect of the leading on the electronic text reading speed was not found.

Results of research can be used to optimize the texts makeup in order to facilitate its perception, which will improve the quality of information assimilation, especially in field of education. Because the research was based on Cyrillic texts it's much of interest to get the same data about Latin ones.

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